

EXPLORE FLIGHT

WE'RE WITH YOU WHEN YOU FLY

Advanced Air Vehicles Program
Leidos Visit
January 9, 2023
Dr. Jim Heidmann
Acting Director, Advanced Air Vehicles Program



NASA Aeronautics – Vision for Aviation in the 21st Century



ARMD continues to evolve and execute the Aeronautics Strategy
<https://www.nasa.gov/aeroresearch/strategy>

6 Strategic Thrusts

 <p>Safe, Efficient Growth in Global Operations</p>	 <p>Safe, Quiet, and Affordable Vertical Lift Air Vehicles</p>
 <p>Innovation in Commercial Supersonic Aircraft</p>	 <p>In-Time System-Wide Safety Assurance</p>
 <p>Ultra-Efficient Subsonic Transports</p>	 <p>Assured Autonomy for Aviation Transformation</p>

U.S. leadership for a new era of flight



ULTRA-EFFICIENT TRANSPORT



FUTURE AIRSPACE



HIGH-SPEED COMMERCIAL FLIGHT

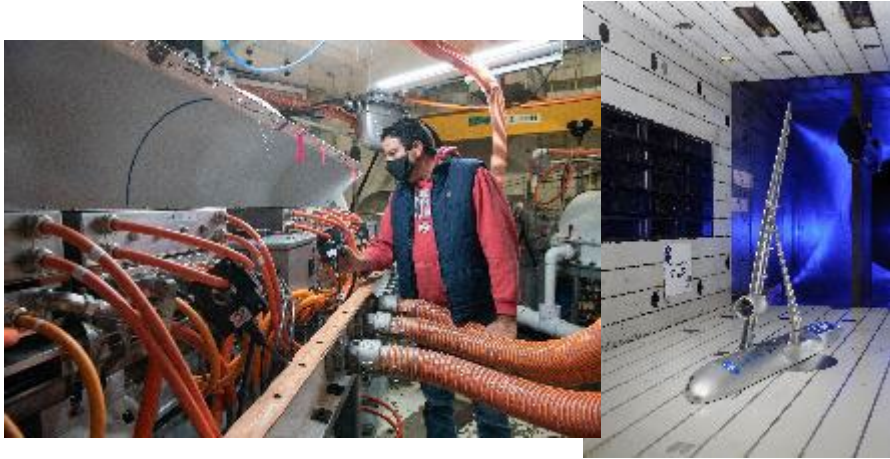


ADVANCED AIR MOBILITY

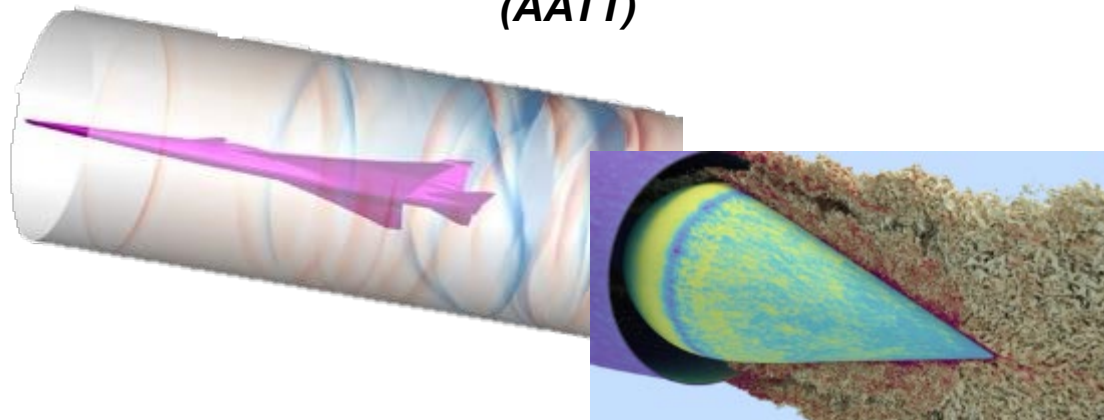
Advanced Air Vehicles Program



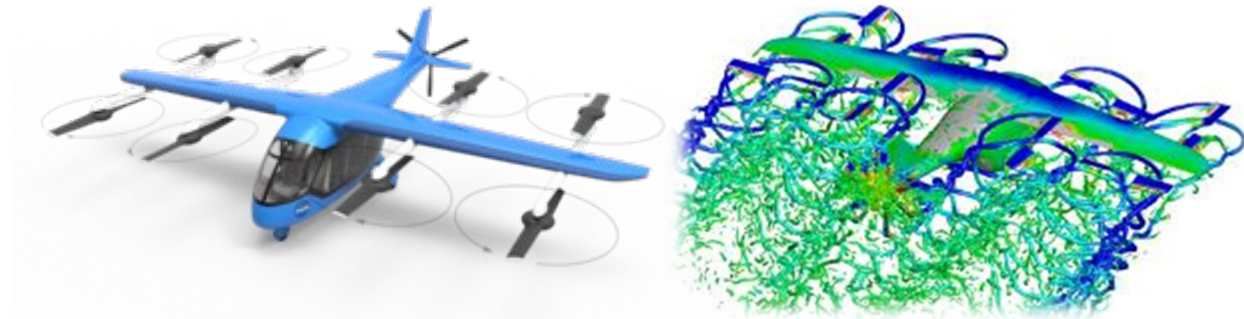
Cutting-edge research that will generate innovative concepts, technologies, capabilities & knowledge to enable revolutionary advances for a wide range of air vehicles



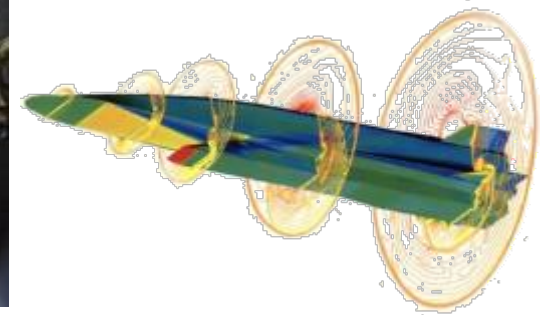
**Advanced Air Transport Technology
(AATT)**



**Commercial Supersonics Technology
(CST)**



**Revolutionary Vertical Lift Technology
(RVLT)**

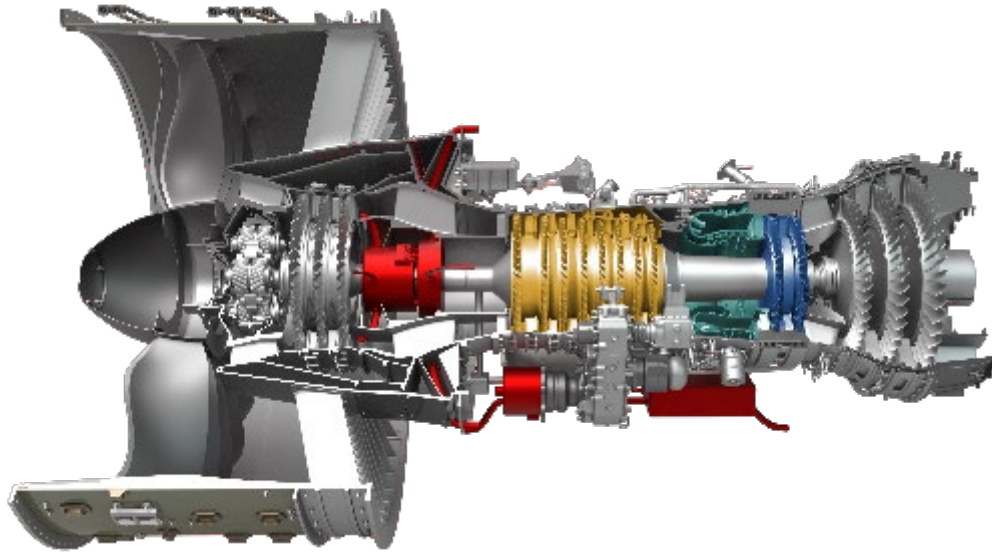


**Hypersonic Technology
(HT)**

Advanced Air Vehicles Program



Accelerating development and demonstration of key technologies



**Hybrid Thermally Efficient Core
(HyTEC)**



**High-rate Composite Aircraft Manufacturing
(HiCAM)**

NASA Hypersonic Applications

HYPERSONICS

Blunt Body Re-entry



Launch



Unpowered Atmospheric Flight

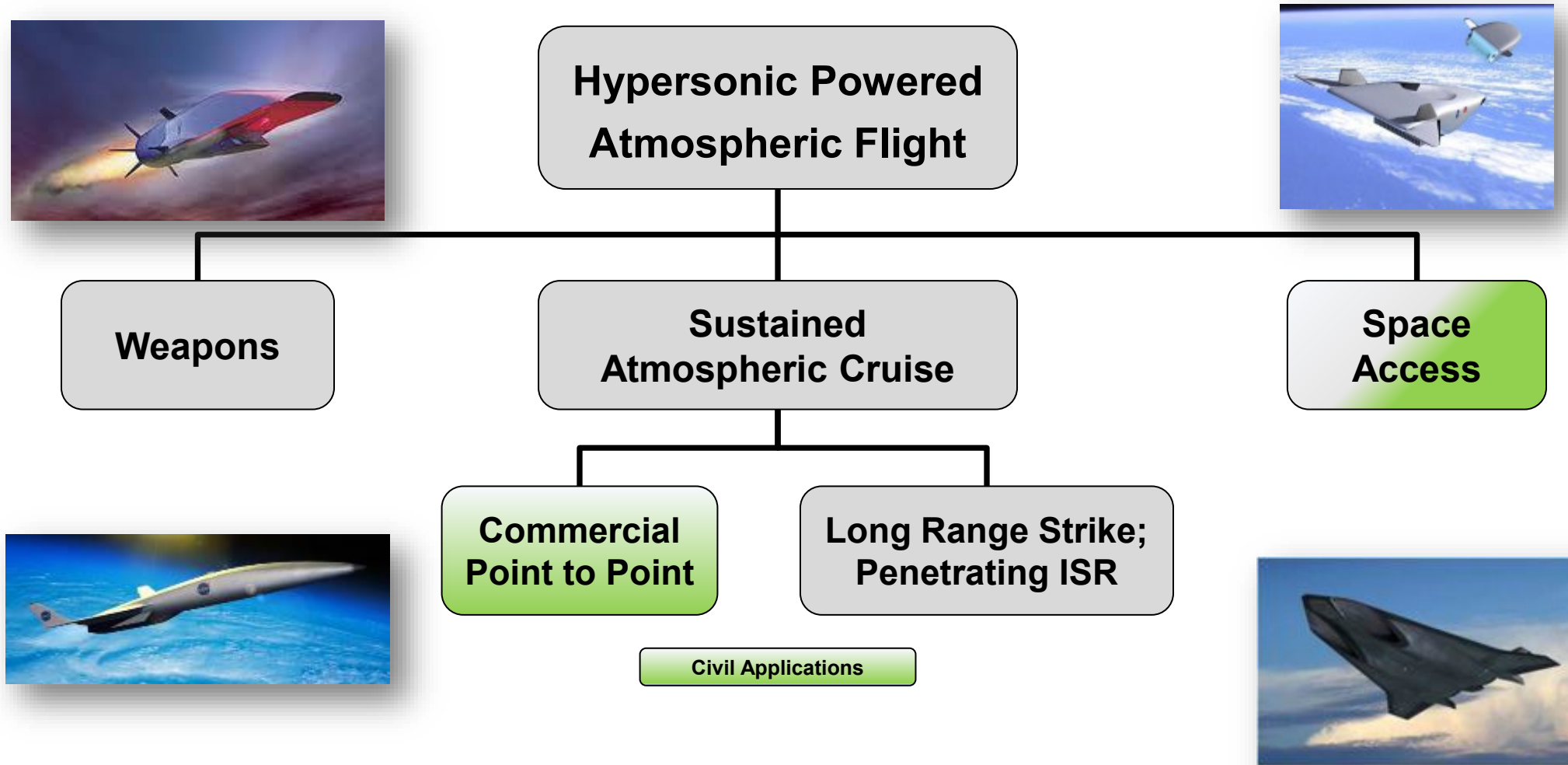


Powered Atmospheric Flight



Multiple NASA applications require mastery of hypersonic flight

HTP Research Focused on Reusable Applications



Partnership between NASA and DoD is critical to progress in hypersonic flight



Hypersonic Technology Project Vision

Enable Routine, Reusable, Airbreathing Hypersonic Flight

Approach

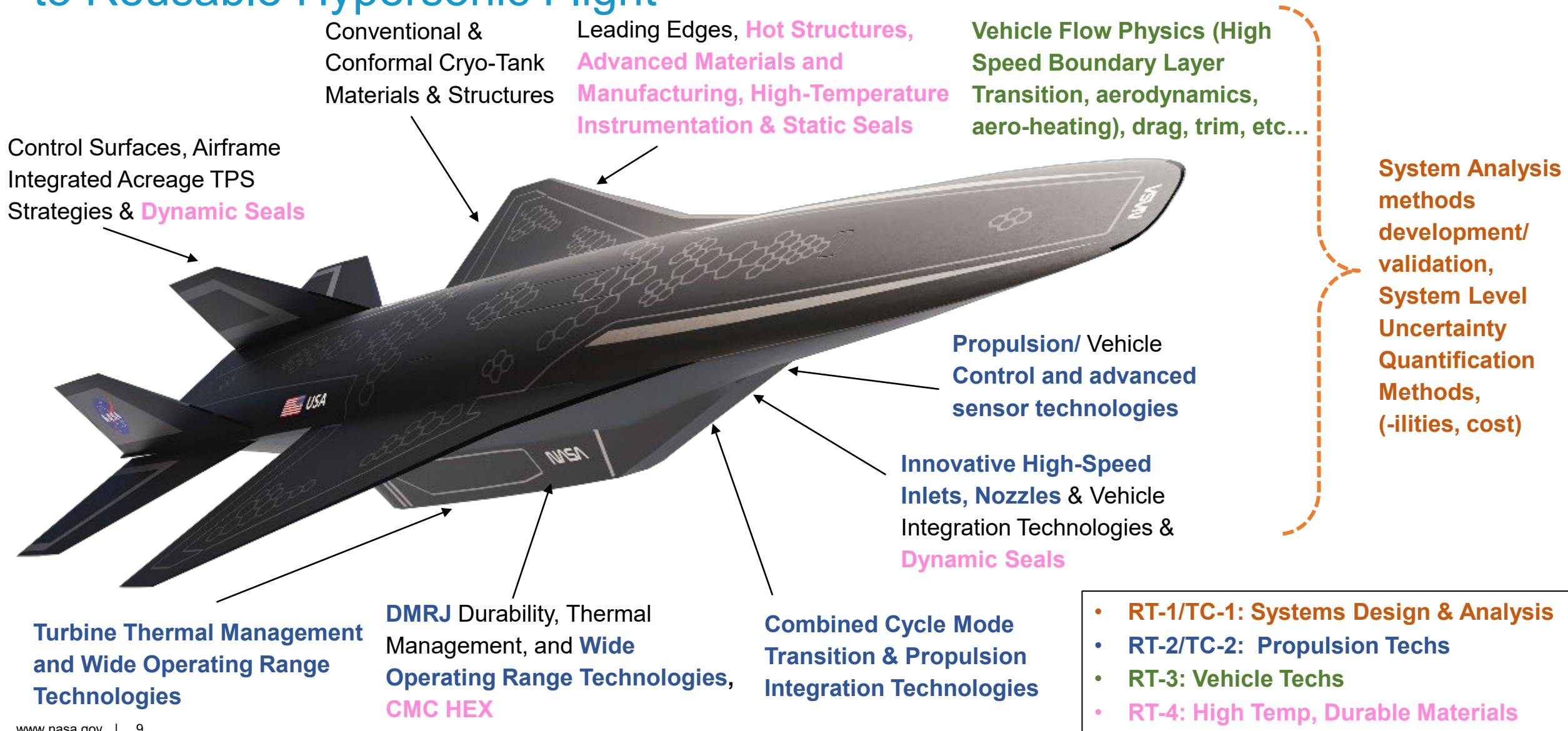
- Conduct fundamental research to enable a broad spectrum of hypersonic systems and missions by advancing the core capabilities and critical technologies underpinning the mastery of hypersonic flight to enable U.S. supremacy in hypersonics

Scope

- Fundamental research spanning technology readiness and system complexity levels
- Critical technologies enabling reusable hypersonic systems
- System-level research, design, analysis, validation
- Engage, invigorate and train the next generation of engineers



HTP Investment Areas in the Common Barriers to Reusable Hypersonic Flight



NASA-DoD Major Collaborations



Hypersonic Airbreathing Weapon Concept (HAWC) USAF-DARPA



- SME support including Airframe IPT lead
- System analysis
- Aero and propulsion analysis ground testing

Advanced Full Range Engine (AFRE) DARPA



- SME support including Propulsion IPT leads
- System studies
- Mode transition design, analysis & testing
- Propulsion testing



HIFIRE-2C AFRL

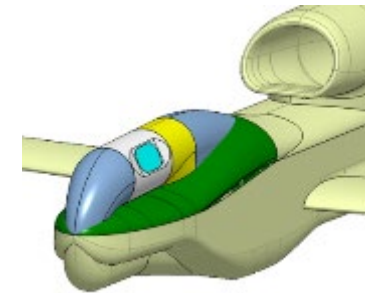
- Joint NASA-AFRL project
- SME support including CE, Co-PI, S&A and ModSim IPT Leads
- Propulsion testing
- CFD

Tactical Boost Glide (TBG) USAF-DARPA



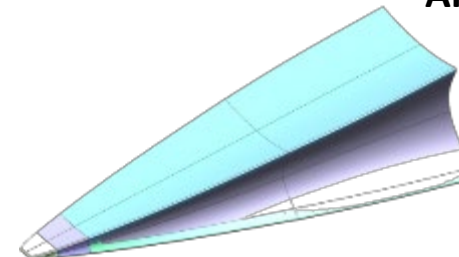
- SME support including Materials IPT lead
- High temp materials analysis, test & database
- Aero/Aerothermal analysis & test

SkyHawk Technology Demonstrations TRMC



- Imaging Instrumentation
- Development and ground test
- Global Hawk Integration
- Flight testing
- Capability Transition Planning

Boundary Layer Transition (BOLT/BOLT2) AFRL-AFOSR



- Testing – ground & launch services
- CFD
- Co-Principal Investigator



RT-2/TC-2: Propulsion Technologies



FY22 Budget \$14.8 M

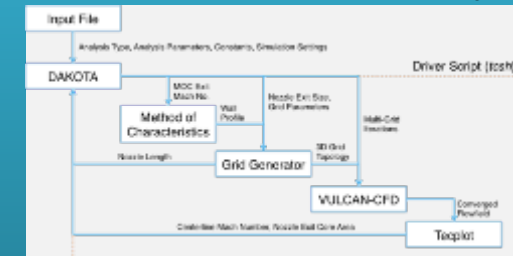
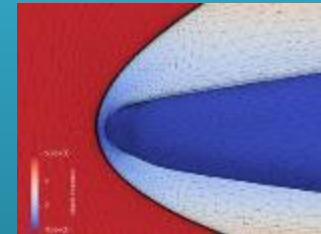
[TC-2] Turbine-Based Combined Cycle (TBCC) Mode Transition

Demonstrate automated control and establish performance/operability assessment methodologies through mode transition for TBCC powered hypersonic vehicles
END DATE: May 2024



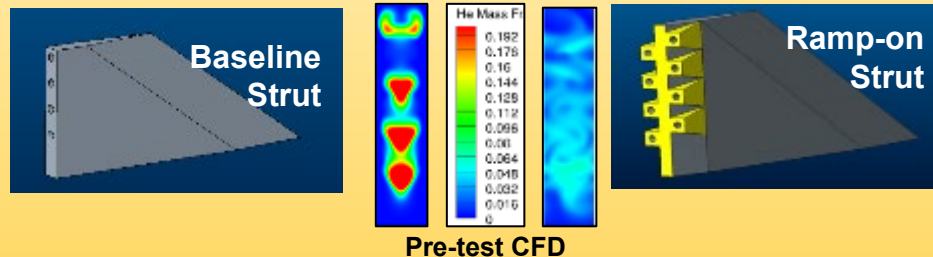
RT-2.2: VULCAN Code Enhancements for Hypersonic Propulsion Analysis

Add uncertainty and optimization capabilities to the VULCAN CFD code for hypersonic propulsion analysis



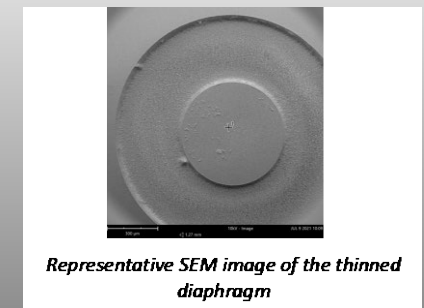
RT-2.1: Enhanced Fuel Injection & Mixing Concepts

Increase fuel/air mixing efficiency(shorter distance and less drag) for scramjet combustors



RT-2.4 Advanced Sensors for Adaptive Controls and Health Monitoring

Develop a robust high temperature SiC high frequency pressure sensor that is both small and durable for reusable DMRJ



Representative SEM image of the thinned diaphragm

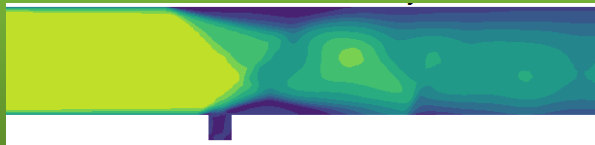
Maturing airbreathing propulsion technologies necessary for hypersonic TBCC vehicles

RT-2/TC-2: Propulsion Technologies (cont'd)

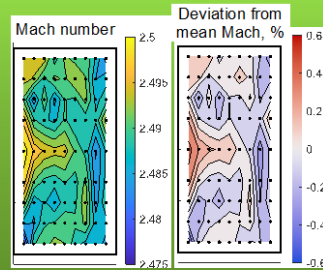


RT-2.6: Isolator Dynamics Research

Develop flow control methods to improve isolator performance and use experimental data to validate CFD uncertainty and turbulence models



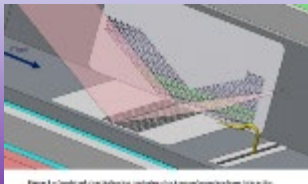
CFD of the shock train-cavity interaction



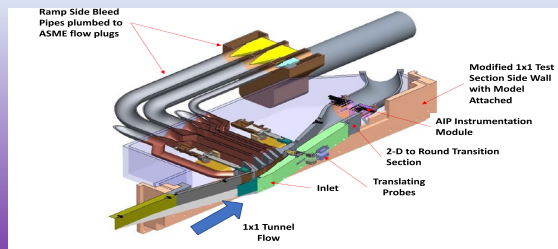
Flow survey at the nozzle exit

RT-2.8: Turboramjet Technology Development

Develop concepts and enabling technologies for turboramjet (TRJ) systems



High Mach bleed research



TRJ Inlet test model conceptual design

RT-2.7: Aether Inlet Model (AIM) high-speed Test

Design and fabricate high-speed inlet model to be one of the test cases for the AETC LARC UPWT CFD evaluation task, to provide experimental data to validate the CFD predicted Aether inlet component performance, and to train the next generation of hypersonic test engineers



Maturing airbreathing propulsion technologies necessary for hypersonic TBCC vehicles



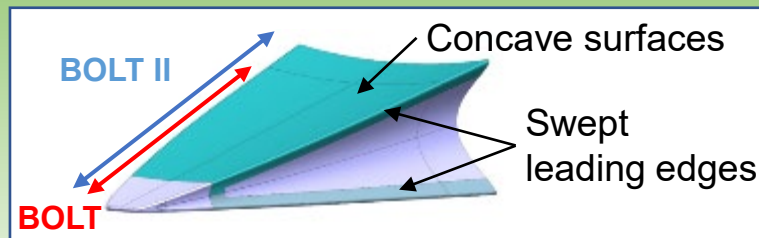
RT-3 Vehicle Technologies Overview



FY22 Budget \$3.0 M

RT-3.1: BOLT Flight Test Support

- BOLT intended to study hypersonic boundary layer transition on complex 3D geometries
 - AFOSR-sponsored sounding rocket project
- Three flights presently manifested
 - BOLT launched @ Esrange, Sweden on Jun 23rd, 2021 (unsuccessful)
 - BOLT II launched @ NASA Wallops on Mar 21st, 2022 (fully successful)
 - BOLT 1B expected to fly ~Sept 2024
- NASA managing roughness experiments on all flights, including wind tunnel tests to support design



AFOSR = Air Force Office of Scientific Research

RT-3.2: University collaborations

- Collaborative studies on fundamental problems with universities working DoD-sponsored research
- Provides access to NASA wind tunnels & expertise
- Supports workforce training
- Ongoing research includes:
 - Shock BL interactions with UTSI/UTSA
 - Fluid structure interactions with UMD
 - Swept fin interactions with Purdue
 - Dynamic balance development with UMD
 - Stag point heating reduction with JHU/APL



Swept Fin Cone Study in the 20-Inch Mach 6 Tunnel

Reducing vehicle level uncertainty and maximizing performance



RT-4: High Temperature, Durable Materials Overview

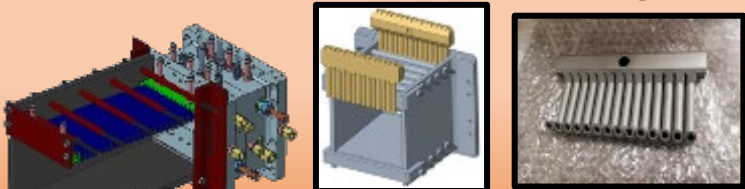


FY22 Budget \$6.9 M

RT-4.1: Composite Matrix Composite Heat Exchanger

Integrated Test Article

- CMCs
- Brazing
- Seals
- Additive Manufacturing



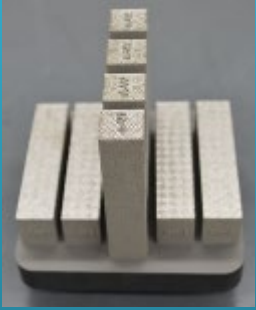
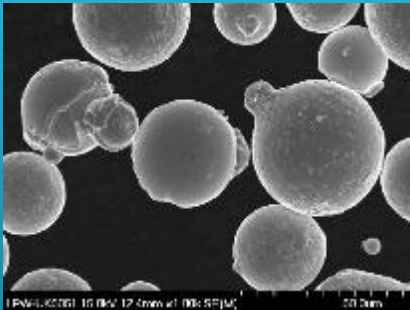
Develop CMC HEX, with no metallic tubes, to improve thermal balance due to reduced cooling reqts

RT-4.4: Additive Manufacturing for Hypersonic Engines

Superalloy Powder

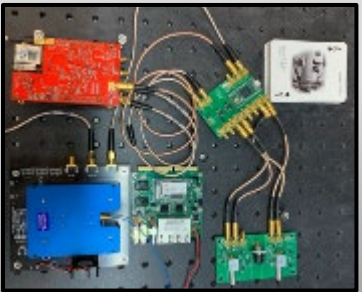
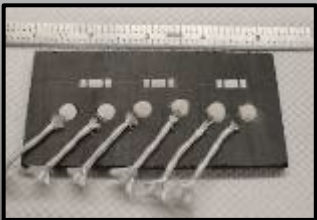
AM Specimen Blanks

AM Varied Shapes



RT-4.5: High Temperature Fiber Optic Sensors

Increase max operating temp of distributed optical strain and temp measurements for ground & flight-testing utilizing femtosecond inscribed fiber Bragg grating (fs-FBG) technology.



RT-4.2: High Temperature Seals



Developing New High Temp Seal Test Rig

Developing & Testing Prototype Aerogel Seals



Developing & Testing Seal Preload Device Designs

Creating lighter, affordable, reusable materials

What Are We Trying To Do?



Enable high-speed
commercial flight

To connect people and businesses faster



Why? – Commercial Market Interest

Favorable High-Speed Market Characteristics

	SAIC (with Bryce Space and Technology)	Deloitte (with SpaceWorks and NIA)
Mach	3	2 to 4 ⁽¹⁾
Range	4,500 nmi	4,000 nmi to 4,500 nmi
Number of routes⁽²⁾	300	90
Aircraft Size (# PAX)	10 GA or 50 Commercial	20 to 50
Aircraft Cost	\$200M to \$300M	\$131M to \$228M ⁽³⁾

References:

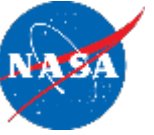
- SAIC Final Report: <https://ntrs.nasa.gov/citations/20210015471>
- Deloitte Final Report: <https://ntrs.nasa.gov/citations/20210014711>

⁽¹⁾ Analysis showed profitable routes up to M5.25

⁽²⁾ Deloitte only considers over-water routes

⁽³⁾ Mach 3 at 4,500 nmi

Summary



NASA hypersonic investments aligned with dual-use/civil applications

Addressing major technical barriers

- System analysis and uncertainty quantification
- Mode transition between a turbine and scramjet
- Fundamental research in aerothermodynamics and materials

Continuing to develop NASA's strategy to support commercial high-speed/hypersonic market

Beginning conceptual vehicle design studies for airbreathing enabled access to space applications

Strongly leveraging partnerships

- NASA leveraging comprehensive DoD ground and flight tests
- NASA facilities and expertise highly valued by government, industry, and academia
- Investing in academic outreach

Working to enable routine, reusable, airbreathing hypersonic flight

